CLAIMS

1. A pn-heterojunction compound semiconductor light-emitting device comprising a crystalline substrate; a lower cladding layer formed on a surface of the crystalline substrate and composed of an n-type Group III-V compound semiconductor; a light-emitting layer formed on a surface of the lower cladding layer and composed of an n-type Group III-V compound semiconductor; an upper cladding layer formed on a surface of the light-emitting layer and composed of p-type boron phosphide; an n-type electrode attached to the lower cladding layer; and a p-type electrode attached to the upper cladding layer, the lower and upper cladding layers being opposed to each other and sandwiching the light-emitting layer, thereby forming, together with the light-emitting layer, a light-emitting portion of a pn-heterojunction structure, wherein the light-emitting device has an intermediate layer composed of an n-type boron-containing Group III-V compound between the light-emitting layer and the upper cladding layer.

2. The pn-heterojunction compound semiconductor light-emitting device according to claim 1, wherein the lower cladding layer is composed of $Al_xGa_yIn_zN$ in which $0 \le X,Y,Z \le 1$ and $X + Y + Z = 1$.

3. The pn-heterojunction compound semiconductor light-emitting device according to claim 1 or claim 2, wherein the light-emitting layer is composed of $Ga_yIn_zN_{1-Q}M_Q$, in which M represents a Group V element other than nitrogen and $0 \leq Q < 1$.

4. The pn-heterojunction compound semiconductor light-emitting device according to any one of claims 1 to 3, wherein the n-type intermediate layer is composed of boron phosphide.

5. The pn-heterojunction compound semiconductor light-emitting device according to any one of claims 1 to 4, wherein the light-emitting layer has an outermost layer composed of an n-type layer of $Ga_XIn_{1-X}N$, in which $0 \leq X \leq 1$, having a crystal face orientation of (0001) and the n-type intermediate layer is composed of an n-type boron-containing Group III-V compound having a crystal face orientation of (111) and is formed on the outermost layer of the light-emitting layer.

6. The pn-heterojunction compound semiconductor light-emitting device according to any one of claims 1 to 5, wherein the n-type intermediate layer is composed of an undoped n-type boron-containing (111)-Group III-V compound whose crystal face orientation of <110> is parallel to an a-axis of an n-type (0001)-$Ga_XIn_{1-X}N$ layer in which $0 \leq X \leq 1$.

7. The pn-heterojunction compound semiconductor light-emitting device according to any one of claims 1 to 6, wherein the n-type intermediate layer has a carrier concentration equal to or lower than that of the p-type boron phosphide layer forming the upper cladding layer provided on the intermediate layer, has a layer thickness of 2 nm to 60 nm and is composed of an undoped n-type boron-containing (111)-Group III-V compound.

8. A method for forming a pn-heterojunction compound semiconductor light-emitting device that comprises a crystalline substrate, a lower cladding layer composed of an n-type Group III-V compound semiconductor, a light-emitting layer composed of an n-type Group III-V compound semiconductor, an upper cladding layer composed of p-type boron phosphide, an n-type electrode attached to the lower cladding layer, and a p-type electrode attached to the upper cladding layer, the upper and lower cladding layer sandwiching the light-emitting layer, said method comprising:

growing the light-emitting layer;

vapor-growing an n-type boron-containing Group III-V compound layer serving as an intermediate layer on the light-emitting layer by use of a source containing a corresponding Group III element and a source containing a corresponding Group V element; and

vapor-growing p-type boron phosphide serving as the upper cladding layer on the intermediate layer wherein a ratio of phosphorus source to boron source is controlled to be lower than a ratio of the Group V element source to the Group III element source employed at the growth of the intermediate layer.

9. The method for forming a pn-heterojunction compound semiconductor light-emitting device according to claim 8, wherein the boron-containing Group III-V compound is boron phosphide.

10. The method for forming a pn-heterojunction compound semiconductor light-emitting device according to claim 8 or claim 9, wherein the upper cladding layer is vapor-grown from raw material having a ratio of phosphorus source to boron source of 5 to 150.

11. The method for forming a pn-heterojunction compound semiconductor light-emitting device according to any one of claims 8 to 10, wherein the intermediate layer is vapor-grown from raw material having a ratio of Group V element source to Group III element source of 150 to 2,000.

12. The method for forming a pn-heterojunction compound semiconductor light-emitting device according to

any one of claims 8 to 11, wherein the light-emitting layer composed of an n-type layer of $Ga_xIn_{1-x}N$, in which $0 \leq X \leq 1$, having a (0001) face serving as an upper surface is grown, and on the light-emitting layer, the intermediate layer composed of an n-type boron-containing (111)-Group III-V compound is formed at 700°C to 950°C and a ratio of Group V element source to Group III element source of 150 to 2,000.

13. The methods for forming a pn-heterojunction compound semiconductor light-emitting device according to any one of claims 8 to 12, wherein the light-emitting layer composed of an n-type layer of $Ga_xIn_{1-x}N$, in which $0 \leq X \leq 1$, having a (0001) face serving as an upper surface is grown, and on the light-emitting layer, the intermediate layer composed of an undoped n-type boron-containing (111)-Group III-V compound whose crystal face orientation of <110> is parallel to an a-axis of the (0001)-$Ga_xIn_{1-x}N$ layer in which $0 \leq X \leq 1$ is formed at a growth rate of 3 nm/min to 300 nm/min.

14. The method for forming a pn-heterojunction compound semiconductor light-emitting device according to any one of claims 8 to 13, wherein the intermediate layer is grown at a growth temperature which is equal to or higher than 700°C and equal to or lower than a growth temperature for forming the p-type boron phosphide layer

that serves as the upper cladding layer, and is formed of an n-type boron-containing (111) Group III-V compound having a carrier concentration equal to or lower than that of the p-type boron phosphide layer.